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Prevalence, Adverse Events, and Factors Associated with Dietary Supplement and Nutritional Supplement Use by US Navy and Marine Corps Personnel

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ABSTRACT

Background About 50% of Americans and 60% to 70% of US military personnel use dietary supplements, some of which have been associated with adverse events (AEs). Nutritional supplements like sport drinks and sport bars/gels are also commonly used by athletes and service members. Previous dietary supplement and nutritional supplement surveys were conducted on Army, Air Force, and Coast Guard personnel.

Objective The aim of this cross-sectional study was to investigate dietary and nutritional supplement use in Navy and Marine Corps personnel, including the prevalence, types, factors associated with use, and AEs.

Design A random sample of 10,000 Navy and Marine Corps personnel were contacted. Service members were asked to complete a detailed questionnaire describing their personal characteristics, supplement use, and AEs experienced.

Results In total, 1,708 service members completed the questionnaire during August through December 2014, with 1,683 used for analysis. Overall, 73% reported using dietary supplements one or more times per week. The most commonly used dietary supplements (used one or more times per week) were multivitamins/multiminerals (48%), protein/amino acids (34%), combination products (33%), and individual vitamins and minerals (29%). About 31% of service members reported using five or more dietary supplements. Sport drinks and sport bars/gels were used by 45% and 23% of service members, respectively. Monthly expenditures on dietary supplements averaged $39; 31% of service members spent ≥$50/mo. Multivariate logistic regression modeling indicated that female sex (women/men; odds ratio [OR]=1.76, 95% CI 1.32 to 2.36), higher educational level (college degree/no college degree; OR=2.23, 95% CI 1.62 to 3.30), higher body mass index (calculated as kg/m^2) (≥30/<25; OR=1.67, 95% CI 1.06 to 2.63), and a greater amount of resistance training (≥271/0 to 45 min/week; OR=2.85, 95% CI 1.94 to 4.17) were associated with dietary supplement use. Twenty-two percent of dietary supplement users and 6% of nutritional supplement users reported one or more AEs. For combination products alone, 29% of users reported one or more AEs.

Conclusions The prevalence of dietary supplement use in Navy and Marine Corps personnel was considerably higher than reported in civilian investigations for almost all types of dietary supplements, although similar to most other military services. Factors associated with dietary supplement use were similar to those reported in previous military and civilian investigations. Prevalence of self-reported AEs was very high, especially for combination products.
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DIETARY SUPPLEMENTS ARE COMMERCIALLY AVAILable products consumed as an addition to the usual diet and include vitamins, minerals, herbs (botanicals), amino acids, and a variety of other products.[1] Marketing claims for some dietary supplements include improvements in overall health status, enhancement of cognitive or physical performance, increases in energy, loss of excess weight, attenuation of pain, and other favorable effects. It is estimated that about 50% of Americans and 60% to 70% of US military personnel use dietary supplements.[2-4] The Dietary Supplement Health and Education Act of 1994[1] established the regulatory framework for dietary supplements in the United

States. Since the Dietary Supplement Health and Education Act became law, US sales of dietary supplements have increased from $4 billion in 1994 to $37 billion in 2014,[5,6] a more than ninefold increase over 20 years.

Reports of adverse events (AEs) associated with dietary supplements have been published regularly,[7-10] and a recent study of a nationally representative sample estimated that 23,005 emergency department visits and 2,154 hospitalizations per year could be attributed to AEs from dietary supplements.[11] The US Food and Drug Administration (FDA) has banned or warned consumers about specific products,[12-14] but under the Dietary Supplement Health and Education Act, the FDA has only limited ability to regulate dietary supplements that might pose safety risks. Manufacturers must notify the FDA 75 days before marketing a new dietary supplement, and although the FDA can review marketing claims, FDA approval is not required for retailing the product. The FDA has the burden of demonstrating that a specific product is unsafe either in the pre- or post-marketing phases before taking action, although since 2007, manufacturers are required to notify the FDA about serious AEs.[15]

Besides dietary supplements, both athletes and military personnel commonly use nutritional supplements like sport drinks, sport bars, sport gels, and meal-replacement beverages. It is estimated that about 25% to 35% of athletes[16] and at least 25% of military personnel[17-19] use nutritional supplements of these types. Sport drinks and sport bars/gels are typically used before, during, or after exercise to provide hydration or nutrients. Sport drinks are generally carbohydrate-electrolyte solutions, while sport bars/gels are generally composed of carbohydrate and protein complexes. Meal-replacement beverages are consumed as a substitute for solid food and are usually used for weight control. These products are classified as nutritional supplements because they are labeled as foods (as opposed to dietary supplements that are labeled as supplements) and are subject to FDA regulation as foods.[20]

An Institute of Medicine report titled "Use of Dietary Supplements by Military Personnel" recognized that a clear picture of use of dietary supplements in the military (eg, prevalence, patterns of use, and AEs) did not exist and recommended conducting surveys to provide detailed information on dietary supplement use by service members.[21] To this end, previous studies were conducted in Army,[17] Air Force,[18] and Coast Guard[19] personnel. The present study was conducted to complete the survey of military services by assessing the types and number of supplements used, factors associated with supplement use, and the incidence of AEs associated with supplement use in active-duty Navy and Marine Corps personnel.

MATERIALS AND METHODS

This investigation was a cross-sectional survey study conducted among US active-duty Navy and Marine Corps personnel and approved by Naval Health Research Center's Institutional Review Board. Investigators requested information from the Defense Manpower Data Center (DMDC) on a random sample of 4,000 Navy personnel (3,000 men and 1,000 women) and 6,000 Marine Corps personnel (4,500 men and 1,500 women) currently on active-duty and with at least 6 months of service as of February 2014 (10,000 personnel in total). Data obtained from DMDC included the service member's name, branch of service, pay grade (rank), postal address, e-mail address, sex, age, marital status, education level, and occupation. The National Change of Address records provided by the US Postal Service were referenced to ensure the most up to date postal address was used.

The random sample request to DMDC was based on previous experience with similar Naval Health Research Center's questionnaire investigations indicating an approximate 20% response rate from Navy and Marine Corps personnel[22] and statistical power considerations. Minimum sample size was determined with the α-error level set at $\leq$.05, β-error at $<$.20 (power$\geq$.80), using the prevalence of Army supplement use of 53%,[17] and the prevalence of exposure of 0.10. If stratified analyses were conducted on the combined Navy and Marine Corps study population, the minimum sample size required to detect a difference equivalent to an odds ratio (OR) of 2.0 was 784.

Recruitment Procedures

Recruitment of participants in the random sample involved a maximum of six sequential contacts. The prospective participant was first sent an introductory postal letter including information about the purpose of the study, the investigators and their command affiliations, the sponsors, and the reason for conducting the study. The introductory letter provided the service member with a pre-incentive $10 gift card to nationally available businesses to encourage participation. The letter also included a description of the survey, a link to a secure website, and a subject identification number that could be used to access the survey and electronically sign the consent form. A follow-up e-mail message after 10 days and postcard after 3 weeks were sent as a reminder to those who did not initially complete the survey. If no response was received after sending the postcard, up to three additional e-mail reminders were sent over 3 months, after which contact with the service member ended. Those who responded were sent "thank you" e-mail messages. All postal and online contacts stated that at any time the service member could decline participation and be removed from the contact list. Recruitment began in August 2014 and no further recruitment was conducted or surveys accepted after December 2014.

Survey (Questionnaire) Description

The first section of the questionnaire was designed to characterize participants. Questions included items on demographics (ie, sex, age, height, weight, marital status, and education level), military characteristics (ie, service, rank, occupation assignment, and special operations status), and physical activity (ie, frequency and duration of aerobic and resistance training). This descriptive section was followed by questions about specific dietary supplements, which included 70 generic dietary supplements and nutritional supplements (eg, multivitamins/multiminerals [MVM], individual vitamins and minerals, amino acids [AA], proteins, sport drinks, sport bars) and 111 brand-name products. The brand-name products were similar to those used in previous studies of Army,[17] Air Force,[18] and Coast Guard[19] personnel, but were updated based on a survey of dietary supplement and nutritional supplement inventories in the Navy and Marine Corps Exchange System and General Nutrition

Center stores on or near Navy and Marine Corps installations. Dietary supplement and nutritional supplement category definitions are provided in the Figure. Service members were asked to estimate how frequently each supplement was used during the past 6 months ("never," "once a month," "once a week," "2 to 6 times/week," or "daily") and to describe any AEs. AEs on the questionnaire were called "side effects" and a list of AEs was located alongside each dietary supplement and nutritional supplement. The AE list included symptoms related to cardiovascular, gastrointestinal, muscular, sleep disturbance, and neurologic symptoms. Specific symptoms listed on the questionnaire included "palpitations, racing heart," "abdominal pain," "nausea/vomiting," "diarrhea," "muscle cramps/pain/weakness," "sleep disturbances/insomnia," "dizziness/confusion/lightheadedness," "tingling/numb in extremities," "seizures/convulsions/tremors," and "other." If "other" was selected by the service member, a space was provided at the bottom of the page to explain the experienced AE.

Data Analysis

All statistical analysis was conducted using the Statistical Package for the Social Sciences (version 19.0.0, 2010, IBM Corp). Body mass index (BMI) was calculated from the questionnaire responses as weight/height^2 (kg/m^2). Weekly duration of aerobic and resistance training was calculated by multiplying weekly exercise frequency (sessions/week) by the duration of training (minutes/session). Prevalences (as a percent) were calculated with their standard error for each dietary supplement, nutritional supplement, and AE. χ^2 Statistics were used to examine differences across various strata of demographics (sex, age, BMI, marital status); military characteristics (service, rank, occupation assignment, special

Classification	Category	Definition
Dietary supplement	Dietary supplement	Any substance defined by the Dietary Supplement Health and Education Act.
	Multivitamin/ multimineral	Dietary supplement containing two or more vitamins and/or two or more minerals with no additional supplement ingredients.
	Protein or amino acid	Amino acid mixtures, protein powders, and similar products where the intent is to provide a single or complex protein source.
	Individual vitamin or mineral	Dietary supplement that is a single vitamin or mineral supplement, such as calcium or vitamin D.
	Herbal supplement	Dietary supplement that includes one or more herbal ingredients with no nutrient or other supplement ingredient. Also includes plant-derived ingredients.
	Purported prohormone	Steroidal hormone or herbal substitute for hormones that were marketed as a dietary supplement and included the Supplement Facts panel on the label.
	Combination product	Dietary supplement with mixtures of ingredients from any of the above categories including two or more categories and multiple ingredients.
	Joint health product	Substance that purports to improve the functioning of body joints, such as glucosamine (with or without chondroitin) or methylsulfonylmethane.
	Other dietary supplement	Other dietary supplement that does not fit into the categories above.
Nutritional supplement	Sport drink	Liquids designed for use before, during, or after physical activity often containing carbohydrates and electrolytes, such as Gatorade[a] and Powerade[b].
	Sport bar or gel	Substances designed to provide nutrients before, during, or after physical activity, such as PowerBar[c], Tiger's Milk[d] (sport bar), PowerBar Gel[c], and Sport Beans[e].
	Meal-replacement beverage	A drink intended as a substitute for a solid food meal, usually with controlled quantities of calories and nutrients, such as meal-replacement shakes.

[a]The Gatorade Company, Inc. PepsiCo.

[b]The Coca-Cola Company.

[c]PowerBar Inc. Nestlé.

[d]Schiff Nutrition International (Reckitt Benckiser Group plc).

[e]Jelly Belly Candy Company.

Figure. Dietary and nutritional supplement categories as defined in study of US Navy and Marine Corps Personnel.

Table 1. Prevalence of reported dietary supplements by demographic and lifestyle characteristics of Navy and Marine Corps personnel

		Dietary Supplements Taken 1 or More Times per Week											
			No. of Dietary Supplements			Dietary Supplement							
Variable	Strata	Any dietary supplement	1 to 2	3 to 4	≥5	MVM[a]	Individual vitamin or mineral	Protein or AA[b]	Combination product	Herbal	Purported prohormone	Joint health product	Other
		%±standard error											
Group	All (n=1,683)	72.7±1.1	27.7±1.1	13.9±0.8	31.1±1.1	48.0±1.2	29.0±1.1	33.6±1.2	33.0±1.1	15.3±0.9	3.8±0.5	8.0±0.7	27.2±1.1
Sex	Male (n=1,198)	71.5±1.3	27.5±1.3	13.4±1.0	30.6±1.3	45.3±1.4	24.1±1.2	37.4±1.4	34.2±1.4	14.4±1.0	4.8±0.6	8.9±0.8	25.8±1.3
	Female (n=485)	75.9±2.0	28.5±1.3	15.3±1.0	32.2±1.4	54.6±2.2	41.0±2.2	24.3±1.9	29.9±2.1	17.3±1.7	1.2±0.5	5.8±1.1	30.5±2.1
		P value[c]											
		0.07	0.29			<0.01	<0.01	<0.01	0.09	0.14	<0.01	0.03	0.05
		%±standard error											
Age	18 to 24 y (n=443)	66.8±2.2	21.9±2.0	10.8±1.5	34.1±2.3	41.1±2.3	28.2±2.1	36.8±2.3	33.6±2.2	14.7±1.7	3.8±0.9	3.6±0.9	23.7±2.0
	25 to 29 y (n=407)	74.7±2.2	29.0±2.2	14.7±1.8	31.0±2.3	48.6±2.5	26.8±2.2	39.1±2.4	32.9±2.3	15.0±1.7	2.7±0.8	7.1±1.3	27.3±2.2
	30 to 39 y (n=552)	75.9±1.8	30.3±2.3	15.0±1.8	30.6±2.3	52.7±2.1	28.4±1.9	32.1±2.0	36.4±2.0	14.5±1.5	3.8±0.8	9.2±1.2	29.2±1.9
	≥40 y (n=280)	73.2±2.6	30.4±2.7	15.4±2.2	27.5±2.7	48.9±3.0	34.6±2.8	23.9±2.5	25.4±2.6	18.2±2.3	5.4±1.4	13.9±2.1	28.6±2.7
		P value[c]											
		0.01	<0.01			<0.01	0.14	<0.01	0.02	0.52	0.36	<0.01	0.25
		%±standard error											
Education	Some HS[d]/HS graduate (n=393)	61.1±2.5	20.4±2.0	12.5±1.7	28.2±2.3	37.9±2.4	23.7±2.1	33.6±2.4	31.8±2.3	13.0±1.7	3.8±1.0	5.1±1.1	21.9±2.1
	Some college/ associates degree (n=729)	77.4±1.5	28.1±1.7	14.0±1.3	35.3±1.8	50.5±1.9	29.8±1.7	35.0±1.8	37.6±1.8	17.8±1.4	4.3±0.8	8.4±1.0	27.3±1.7
	Bachelors/ graduate degree (n=561)	74.9±1.9	32.4±2.0	14.8±1.5	27.6±1.9	51.9±2.1	31.7±2.0	31.9±2.0	27.8±1.9	13.5±1.4	3.2±0.7	9.6±1.2	30.7±1.9
		P value[c]											
		<0.01	<0.01			<0.01	0.02	0.51	<0.01	0.04	0.62	0.04	0.01

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Table 1. Prevalence of reported dietary supplements by demographic and lifestyle characteristics of Navy and Marine Corps personnel (*continued*)

		Dietary Supplements Taken 1 or More Times per Week											
			No. of Dietary Supplements			Dietary Supplement							
Variable	Strata	Any dietary supplement	1 to 2	3 to 4	≥5	MVM[a]	Individual vitamin or mineral	Protein or AA[b]	Combination product	Herbal	Purported prohormone	Joint health product	Other
		%±standard error											
Marital status	Single (n=570)	70.4±1.9	22.1±1.7	14.7±1.5	33.5±2.0	47.9±2.1	32.8±2.0	36.7±2.0	34.9±2.0	14.7±1.5	2.8±0.7	6.5±1.0	26.7±1.9
	Married (n=1,113)	73.9±1.3	30.6±1.4	13.5±1.0	29.8±1.4	48.1±1.5	27.0±1.3	32.1±1.4	32.0±1.4	15.5±1.1	4.3±0.6	8.8±0.8	27.4±1.3
		P value[c]											
		0.12	<0.01			0.95	0.01	0.06	0.23	0.66	0.13	0.10	0.75
		%±standard error											
Rank	Junior Enlisted (n=442)	66.5±2.2	24.2±2.0	10.4±1.5	31.9±2.2	41.2±2.3	29.9±2.2	35.3±2.3	32.1±2.2	12.7±1.6	3.8±0.9	3.4±0.9	23.1±2.0
	Senior enlisted (n=786)	75.6±1.5	28.0±1.6	14.8±1.3	32.8±1.7	49.0±1.8	27.4±1.6	34.5±1.7	37.7±1.7	17.7±1.4	4.8±0.8	9.9±1.1	27.2±1.6
	Warrant Officer (n=38)	73.7±7.1	23.7±6.9	7.9±4.4	42.1±8.0	63.2±7.8	39.5±7.9	28.9±7.4	44.7±8.1	10.5±5.0	2.6±2.6	7.9±4.4	26.3±7.1
	Junior Officer (n=235)	75.3±2.8	33.2±3.1	15.7±2.4	26.4±2.9	52.8±3.3	26.8±2.9	34.0±3.1	27.2±2.9	12.8±2.2	1.3±0.7	6.8±1.6	30.6±3.0
	Senior Officer (n=182)	72.0±3.3	29.1±3.4	17.6±2.8	25.3±3.2	51.1±3.7	34.6±3.5	26.4±3.3	19.8±3.0	15.4±2.7	2.7±1.2	12.6±2.5	32.4±3.5
		P value[c]											
		0.01	<0.01			<0.01	0.16	0.24	<0.01	0.11	0.13	<0.01	0.10
		%±standard error											
Occupational assignment group	Combat arms (n=483)	72.7±2.0	26.7±2.0	14.3±1.6	31.7±2.1	48.2±2.3	27.5±2.0	35.6±2.2	33.5±2.1	14.1±1.6	3.5±0.8	9.7±1.3	29.8±2.1
	Combat support (n=479)	74.1±2.0	27.6±2.0	15.7±1.7	30.9±2.1	46.1±2.3	29.4±2.1	35.5±2.2	34.0±2.2	18.0±1.8	3.5±0.8	7.7±1.2	26.9±2.0
	Combat service support (n=656)	71.5±1.8	27.9±1.8	12.2±1.3	31.4±1.8	48.3±2.0	30.3±1.8	31.1±1.8	32.3±1.8	14.5±1.4	4.4±0.8	7.0±1.0	25.0±1.7
		P value[c]											
		0.62	0.76			0.73	0.59	0.18	0.82	0.18	0.66	0.24	0.31

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Table 1. Prevalence of reported dietary supplements by demographic and lifestyle characteristics of Navy and Marine Corps personnel (*continued*)

		Dietary Supplements Taken 1 or More Times per Week											
			No. of Dietary Supplements			Dietary Supplement							
Variable	Strata	Any dietary supplement	1 to 2	3 to 4	≥5	MVM[a]	Individual vitamin or mineral	Protein or AA[b]	Combination product	Herbal	Purported prohormone	Joint health product	Other
		%±standard error											
Body mass index[e]	<25 (n=659)	70.0±1.8	29.1±1.8	14.1±1.4	26.7±1.7	46.3±1.9	29.7±1.8	28.7±1.8	26.4±1.7	12.9±1.3	1.1±0.4	6.2±0.9	25.6±1.7
	25 to 29.9 (n=844)	73.9±1.5	27.5±1.5	14.1±1.2	32.3±1.6	48.1±1.7	28.0±1.5	37.2±1.7	36.6±1.7	15.2±1.2	5.7±0.8	9.5±1.0	27.3±1.5
	≥30.0 (n=163)	77.3±3.3	24.5±3.4	12.9±2.6	39.9±3.8	54.0±3.9	30.1±3.6	33.7±3.7	41.7±3.9	24.5±3.4	4.9±1.7	8.0±2.1	31.3±3.6
		P value[c]											
		0.09	0.04			0.21	0.71	<0.01	<0.01	<0.01	<0.01	0.07	0.34
		%±standard error											
Aerobic exercise duration	0 to 100 min/wk (n=414)	71.0±2.2	27.5±2.2	15.2±1.8	28.3±2.2	47.8±2.5	29.5±2.2	30.4±2.3	32.1±2.3	13.3±1.7	2.9±0.8	6.5±1.2	24.4±2.1
	101 to 180 min/wk (n=384)	70.8±2.3	29.9±2.3	15.1±1.8	25.8±2.2	46.4±2.5	27.1±2.3	27.1±2.3	28.9±2.3	13.5±1.7	3.6±1.0	7.6±1.4	23.4±2.2
	181 to 290 min/wk (n=462)	74.9±2.0	29.4±2.1	12.6±1.5	32.9±2.2	47.6±2.3	28.1±2.1	36.4±2.2	34.0±2.2	16.7±1.7	4.3±0.9	8.0±1.3	30.7±2.1
	≥291 min/wk (n=409)	74.6±2.2	23.5±2.1	13.4±1.7	37.7±2.4	50.6±2.5	32.3±2.3	40.3±2.4	37.4±2.4	17.4±1.9	4.4±1.0	10.3±1.5	30.1±2.3
		P value[c]											
		0.38	<0.01			0.67	0.40	<0.01	0.08	0.24	0.64	0.25	0.03
		%±standard error											
Resistance training duration	0 to 45 min/wk (n=402)	65.4±2.4	36.6±2.4	11.9±1.6	16.9±1.9	41.5±2.5	25.4±2.2	12.9±1.7	19.7±2.0	13.9±1.7	1.2±0.5	6.2±1.2	20.9±2.0
	46 to 135 min/wk (n=470)	70.4±2.1	29.8±2.1	14.7±1.6	26.0±2.0	47.7±2.3	30.2±2.1	23.8±2.0	26.8±2.0	15.7±1.7	1.3±0.5	7.2±1.2	26.2±2.0
	136 to 270 min/wk (n=395)	79.2±2.0	24.8±2.2	17.0±1.9	37.5±2.4	52.7±2.5	33.2±2.4	44.1±2.5	39.7±2.5	18.0±1.9	5.8±1.2	10.4±1.5	30.6±2.3
	≥271 min/wk (n=389)	78.7±2.1	19.0±2.0	12.9±1.7	46.8±2.5	51.4±2.5	28.8±2.3	57.3±2.5	49.1±2.5	13.9±1.8	7.7±1.4	9.0+1.5	32.1±1.4
		P value[c]											
		<0.01	<0.01			<0.01	0.11	<0.01	<0.01	0.33	<0.01	0.14	<0.01

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Table 1. Prevalence of reported dietary supplements by demographic and lifestyle characteristics of Navy and Marine Corps personnel (*continued*)

		Dietary Supplements Taken 1 or More Times per Week											
			No. of Dietary Supplements			Dietary Supplement							
Variable	Strata	Any dietary supplement	1 to 2	3 to 4	≥5	MVM[a]	Individual vitamin or mineral	Protein or AA[b]	Combination product	Herbal	Purported prohormone	Joint health product	Other
		%±standard error											
Special Operations	No (n=1,632)	72.7±1.1	27.8±1.1	13.9±0.9	30.9±1.1	47.7±1.2	29.0±1.1	33.5±1.2	33.1±1.2	15.1±0.9	3.8±0.5	7.8±0.7	26.5±1.1
	Yes (n=41)	80.5±6.2	29.3±7.1	12.2±5.1	39.0±7.6	58.5±7.7	34.1±7.4	46.3±7.8	31.7±7.3	17.1±5.9	4.9±3.4	14.6±5.5	48.8±7.8
		P value[c]											
		0.27	0.60			0.17	0.47	0.09	0.85	0.73	0.72	0.11	<0.01
		%±standard error											
Service	Navy (n=700)	70.7±1.7	28.6±1.7	13.3±1.3	28.9±1.7	48.6±1.9	29.6±1.7	30.3±1.7	29.9±1.7	15.4±1.4	2.7±0.6	8.3±1.0	28.6±1.7
	Marine Corps (n=983)	74.2±1.4	27.2±1.4	14.3±1.1	32.7±1.5	47.6±1.6	28.6±1.4	36.0±1.5	35.2±1.5	15.2±1.1	4.6±0.7	7.8±0.9	26.1±1.4
		P value[c]											
		0.12	0.23			0.70	0.66	0.01	0.02	0.88	0.05	0.74	0.27

[a]MVM=multivitamin/multimineral.
[b]AA=amino acid.
[c]From χ^2 analysis.
[d]HS=high school.
[e]Calculated as kg/m^2.

operations status); and physical activity (weekly frequency of aerobic and resistance training). The amount of money spent on dietary supplements per month in the past 6 months was analyzed using a one-way analysis of variance across strata of demographic characteristics, military characteristics, and physical activity. Multivariate logistic regression examined associations between independent variables involving demographic characteristics, military characteristics, and physical activity and dependent variables that included any dietary supplement, any nutritional supplement, MVM, protein/AA, herbals, more than five dietary supplements, and spending >$50/mo on dietary supplements. Because some participants did not complete all questions, the number of subjects is shown for each variable.

To address response bias, analyses were performed on the characteristics of service members who did (responders) and did not (nonresponders) complete the survey in the deidentified random-sample data obtained from DMDC. χ^2 Analyses compared responders and nonresponders in terms of sex, rank, marital status, education level, occupational group, and military service; *t* tests were used to assess age differences.

RESULTS

Of the random sample of 10,000 active-duty service members requested from DMDC, 328 were not contacted because they were enrolled in other Naval Health Research Center's military survey studies.[22,23] Therefore, 9,672 (5,810 Marines and 3,862 Navy personnel) were initially contacted, 9,598 by postal letter, and 74 without valid postal addresses who were contacted by e-mail. Of the invited service members, 999 Marine Corps (17.2%) and 709 Navy (18.4%) completed the questionnaire (17.7% total response rate). Sixteen Marines and 9 Navy personnel reported service in the reserves and were not considered further. This resulted in a final sample of 983 Marine Corps and 700 Navy active-duty personnel who were included in the analyses.

Dietary and Nutritional Supplement Use

Table 1 provides prevalence and number of dietary supplements taken during the past 6 months for the Marine Corps and Navy personnel surveyed. Seventy-three percent reported using one or more dietary supplements one or more times per week. A larger proportion of women reported taking MVMs, individual vitamins and minerals, and other dietary supplements; a greater proportion of men reported taking protein/AA supplements, supplements purportedly containing prohormones, and joint health products. A smaller proportion of the youngest service members reported taking dietary supplements, especially MVMs and joint health products; the 25- to 29-year-olds reported the highest prevalence of proteins/AAs, while the 30- to 39-year-olds reported the greatest use of combination products. Although younger service members reported taking fewer dietary supplements overall, those who did use dietary supplements reported taking a great number of supplements (five or more dietary supplements one or more times per week). A higher proportion of service members with some college reported using dietary supplements of any type, including combination products, and herbal substances; those with college degrees were more likely to report use of MVMs, individual vitamins and minerals, joint heath products, and other dietary supplements. A greater number of concurrent dietary supplements were used by a greater proportion of those with some college or an associate's degree. Compared with married service members, a larger proportion of single service members reported concurrently taking multiple supplements and consuming individual vitamins or minerals. Compared with those of other ranks, a smaller proportion of junior enlisted personnel (E1 to E4) reported using dietary supplements, especially MVMs and joint health products. Compared with officers, a greater proportion of enlisted service members and warrant officers reported using a greater number of supplements (more than five) and using more combination products. Senior enlisted and senior officers were more likely to use joint health products than junior enlisted and junior officers. There was no difference in reported prevalence of dietary supplement use by occupational assignment group. Compared with those with BMI <25, a larger proportion of those with BMI ≥25 reported concurrently consuming a greater number of dietary supplements, especially protein/AAs, combination products, herbals, and purported prohormones. Individuals performing more weekly aerobic exercise reported consuming a greater number of dietary supplements and were more likely to use proteins/AAs and other dietary supplements. For resistance training, there was a positive association (ie, more resistance training, higher use prevalence) with many dietary supplements; service members reporting more weekly resistance training consumed a greater number of dietary supplements and used more dietary supplements overall, especially MVMs, proteins/AAs, combination products, purported prohormones, and other dietary supplements. Special Operations personnel were generally greater users of dietary supplements than all other service members; however, this could not be supported statistically, likely due to the small sample size of Special Operations personnel (2.5% of the study population). Compared with Navy personnel, a greater proportion of Marine Corps personnel reported use of protein/AA supplements, combination products, and purported prohormones. Compared with Navy personnel, Marines reported more (mean±standard deviation) aerobic (265±280 min/wk vs 224±261 min/wk; $P<0.01$) and resistance training (249±296 min/wk vs 187±285 min/wk; $P<0.01$) activity.

Table 2 provides the prevalence of nutritional supplements consumed during the past 6 months by Navy and Marine Corps personnel. Fifty-three percent reported using one or more nutritional supplements one or more times per week. Compared with women, a larger proportion of men used nutritional supplements, especially sport drinks; a larger proportion of women reported using meal-replacement beverages. A larger proportion of younger service members consumed sport drinks. A larger proportion of those with higher educational levels were likely to consume sport bars/gels, but less likely to use sport drinks. Marital status had little association with dietary supplement use. Compared with officers, a greater proportion of enlisted personnel and warrant officers used sport drinks, but were generally less likely to use sport bars/gels. A greater proportion of combat arms personnel used nutritional supplements, especially sport drinks and sport bars/gels, and sport bars/gels consumption was similar among the combat arms and combat support personnel. BMI had little association with nutritional

Table 2. Prevalence of reported nutritional supplements and dollars spent on dietary supplements by demographic and lifestyle characteristics of Navy and Marine Corps personnel

		Nutritional Supplements Taken 1 or More Times per Week					
Variable	Strata	Any NS[a]	Any sport drink	Any sport bar or gel	Any meal-replacement beverage	Money spent on DS[b] in last 6 months, $±SD[c]	≥$50 Spent on DSs in last 6 months, %±SE[d]
		←%±SE→					
Group	All (n=1,683)	53.1±1.2	44.5±1.2	22.8±1.0	6.8±0.6	39±2	30.8±1.1
Sex	Male (n=1,198)	55.8±1.4	47.8±1.4	23.9±1.2	5.8±0.7	42±2	32.8±1.4
	Female (n=485)	46.4±2.3	36.3±2.2	20.0±1.8	9.3±1.3	32±3	25.5±2.0
		←*P value*[e]→					
		<0.01	<0.01	0.09	0.01	0.01	0.01
		←%±SE→					
Age	18 to 24 y (n=443)	57.1±2.4	51.5±2.4	19.2±1.9	5.2±1.1	42±3	34.7±2.3
	25 to 29 y (n=407)	51.8±2.5	43.7±2.5	22.9±2.1	6.6±1.2	37±3	30.7±2.3
	30 to 39 y (n=552)	52.7±2.1	42.6±2.1	24.5±1.8	7.6±1.1	42±3	30.8±2.0
	≥40 y (n=280)	49.6±3.0	38.9±2.9	25.0±2.6	8.2±1.6	32±3	25.1±2.6
		←*P value*[e]→					
		0.21	<0.01	0.18	0.35	0.15	0.17
		←%±SE→					
Education	Some HS[f]/HS graduate (n=393)	54.7±2.5	49.6±2.5	15.8±1.8	4.6±1.1	49±4	36.3±2.4
	Some college/associates degree (n=729)	53.2±1.8	45.3±1.8	20.4±1.5	8.0±1.0	40±2	33.1±1.7
	Bachelors/graduate degree(n=561)	51.9±2.1	39.9±2.1	30.7±1.9	7.0±1.1	31±2	24.5±1.8
		←*P value*[e]→					
		0.69	0.01	<0.01	0.10	<0.01	<0.01
		←%±SE→					
Marital Status	Single (n=570)	53.2±2.1	45.6±2.1	23.9±1.8	7.2±1.1	42±3	33.9±2.0
	Married (n=1,113)	52.9±1.5	43.9±1.5	22.2±1.2	6.6±0.7	38±2	29.2±1.4
		←*P value*[e]→					
		0.82	0.51	0.44	0.68	0.26	0.10

(*continued on next page*)

Table 2. Prevalence of reported nutritional supplements and dollars spent on dietary supplements by demographic and lifestyle characteristics of Navy and Marine Corps personnel (*continued*)

Variable	Strata	Nutritional Supplements Taken 1 or More Times per Week: Any NS[a]	Any sport drink	Any sport bar or gel	Any meal-replacement beverage	Money spent on DS[b] in last 6 months, $±SD[c]	≥$50 Spent on DSs in last 6 months, %±SE[d]
		←%±SE→					
Rank	Junior Enlisted (n=442)	55.2±2.4	49.5±2.4	17.6±1.8	5.4±1.1	41±3	33.6±2.2
	Senior Enlisted (n=786)	52.7±1.8	44.5±1.8	20.9±1.5	7.5±0.9	44±3	34.3±1.7
	Warrant Officer (n=38)	55.3±8.1	44.7±8.1	28.9±7.4	7.9±4.4	32±8	27.6±7.3
	Junior Officer (n=235)	50.6±3.3	39.6±3.2	32.8±3.1	5.1±1.4	26±3	21.6±2.7
	Senior Officer (n=182)	52.7±3.7	38.5±3.6	29.1±3.4	9.3±2.2	32±4	23.0±3.1
		←*P value*[e]→					
		0.83	0.05	<0.01	0.30	<0.01	<0.01
		←%±SE→					
Occupational assignment group	Combat arms (n=483)	59.4±2.2	52.6±2.3	25.9±2.0	7.5±1.2	38±3	31.6±2.1
	Combat support (n=479)	53.0±2.3	42.2±2.3	24.6±2.0	6.7±1.1	39±3	29.6±2.1
	Combat service support (n=656)	50.0±2.0	41.9±1.9	20.0±1.6	6.7±1.0	40±3	30.9±1.8
		←*P value*[e]→					
		<0.01	<0.01	0.04	0.86	0.77	0.86
		←%±SE→					
Body mass index[g]	<25 (n=659)	51.1±1.9	44.2±1.9	21.4±1.6	5.2±0.9	28±2	24.7±1.7
	25 to 29.9 (n=844)	54.3±1.7	44.9±1.7	24.3±1.5	7.7±0.9	45±3	33.9±1.6
	≥30.0 (n=163)	55.2±3.9	45.4±3.9	20.2±3.1	8.6±2.2	48±5	37.4±3.8
		←*P value*[e]→					
		0.41	0.94	0.30	0.10	<0.01	<0.01
		←%±SE→					
Aerobic exercise duration	0 to 100 min/wk (n=414)	47.8±2.5	41.1±2.4	16.7±1.8	7.0±1.3	36±4	25.5±2.1
	101 to 180 min/wk (n=384)	50.3±2.6	40.9±2.5	20.3±2.1	4.9±1.1	32±3	25.4±2.2
	181 to 290 min/wk (n=462)	56.5±2.3	47.6±2.3	27.7±2.1	7.6±1.2	40±3	32.6±2.2
	≥291 min/wk (n=409)	58.4±2.4	48.9±2.5	26.2±2.2	7.8±1.3	47±3	38.9±2.4
		←*P value*[e]→					
		<0.01	0.03	<0.01	0.37	0.01	<0.01

(*continued on next page*)

Table 2. Prevalence of reported nutritional supplements and dollars spent on dietary supplements by demographic and lifestyle characteristics of Navy and Marine Corps personnel (*continued*)

		Nutritional Supplements Taken 1 or More Times per Week					
Variable	Strata	Any NS[a]	Any sport drink	Any sport bar or gel	Any meal-replacement beverage	Money spent on DS[b] in last 6 months, $±SD[c]	≥$50 Spent on DSs in last 6 months, %±SE[d]
		←%±SE→					
Resistance training duration	0 to 45 min/wk (n=402)	45.0±2.5	36.3±2.4	16.4±1.8	6.7±1.2	20±2	12.1. ±1.6
	46 to 135 min/wk (n=470)	54.3±2.3	46.4±2.3	23.8±2.0	6.0±1.1	29±2	23.7±2.0
	136 to 270 min/wk (n=395)	56.2±2.5	46.8±2.5	27.6±2.2	8.9±1.4	44±3	38.7±2.5
	≥271 min/wk (n=389)	59.1±2.5	50.1±2.5	24.2±2.2	6.4±1.2	66±5	51.0±2.5
		←*P value*[e]→					
		<0.01	<0.01	<0.01	0.37	<0.01	<0.01
		←%±SE→					
Special Operations	No (n=1,632)	52.5±1.2	44.2±1.2	22.4±1.0	6.8±0.6	39±2	30.3±1.1
	Yes (n=41)	75.6±5.7	56.1±7.8	43.9±7.8	7.3±4.1	54±10	50.0±7.8
		←*P value*[e]→					
		<0.01	0.13	<0.01	0.90	0.13	0.02
		←%±SE→					
Service	Navy (n=700)	47.7±1.9	36.1±1.8	23.3±1.6	7.4±1.0	35±2	27.2±1.7
	Marine Corps (n=983)	57.0±1.6	50.5±1.6	22.4±1.3	6.4±0.8	42±2	33.3±1.5
		←*P value*→					
		<0.01	<0.01	0.66	0.41	0.04	0.03

[a]NS=nutritional supplement.
[b]DS=dietary supplement.
[c]SD=standard deviation.
[d]SE=standard error.
[e]From χ^2 analyses.
[f]HS=high school.
[g]Calculated as kg/m^2.

Table 3. Factors associated with dietary and nutritional supplement use among Navy and Marine Corps personnel[a]

Variable	Strata	Dietary Supplements Taken 1 or More Times per Week							Any NS[e] taken 1 or more times per week
		Any DS[b]	Use of ≥5 DSs	MVM[c]	Protein or AA[d]	Combination products	Herbal	≥$50 Spent on DSs per month	
		odds ratio (95% CI)							
Sex	Male	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Female	1.76 (1.32-2.36)	1.37 (1.04-1.81)	1.85 (1.44-2.39)	0.62 (0.46-0.83)	1.12 (0.85-1.48)	1.56 (1.11-2.18)	0.91 (0.64-1.30)	0.68 (0.53-0.87)
Age	18 to 24 y	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	25 to 29 y	1.18 (0.84-1.67)	0.83 (0.59-1.15)	1.25 (0.92-1.70)	0.93 (0.66-1.30)	0.97 (0.69-1.34)	0.99 (0.66-1.51)	1.00 (0.67-1.51)	0.74 (0.54-1.00)
	30 to 39 y	1.36 (0.95-1.96)	0.95 (0.68-1.34)	1.58 (1.15-2.17)	0.86 (0.60-1.22)	1.45 (1.03-2.04)	0.91 (0.59-1.40)	1.28 (0.83-1.96)	0.78 (0.57-1.07)
	≥40 y	1.30 (0.84-2.02)	0.89 (0.58-1.37)	1.43 (0.97-2.12)	0.56 (0.35-0.87)	0.89 (0.58-1.38)	1.28 (0.77-2.14)	1.08 (0.63-1.85)	0.67 (0.54-1.00)
Education	Some HS[f]/HS graduate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Some college	2.27 (1.68-3.06)	1.81 (1.33-2.45)	1.59 (1.21-2.10)	1.44 (1.06-1.97)	1.48 (1.10-1.99)	1.47 (1.00-2.17)	1.10 (0.76-1.59)	1.16 (0.88-1.53)
	College degree	2.23 (1.62-3.30)	1.49 (1.03-2.14)	1.77 (1.28-2.45)	1.66 (1.16-2.40)	1.10 (0.77-1.57)	1.11 (0.70-1.76)	0.84 (0.54-1.31)	1.16 (0.84-1.61)
Marital status	Single	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Married	1.14 (0.87-1.49)	0.94 (0.73-1.22)	0.98 (0.77-1.25)	0.90 (0.69-1.17)	0.83 (0.64-1.07)	1.09 (0.78-1.51)	0.73 (0.53-1.00)	0.95 (0.75-1.21)
Occupational assignment group	Combat arms	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Combat support	1.11 (0.81-1.51)	0.87 (0.65-1.17)	0.90 (0.69-1.18)	0.98 (0.73-1.33)	0.97 (0.72-1.30)	1.26 (0.87-1.81)	0.86 (0.60-1.23)	0.76 (0.58-1.00)
	Combat service support	0.90 (0.68-1.19)	0.92 (0.70-1.21)	0.92 (0.77-1.18)	0.87 (0.65-1.15)	0.93 (0.70-1.22)	0.99 (0.69-1.41)	0.96 (0.69-1.35)	0.70 (0.54-0.90)
Body mass index[g]	<25.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	25.0 to 29.9	1.26 (0.98-1.63)	1.48 (1.15-1.91)	1.19 (0.95-1.49)	1.46 (1.13-1.89)	1.70 (1.32-2.19)	1.32 (0.96-1.82)	1.67 (1.21-2.31)	1.08 (0.86-1.36)
	≥30.0	1.67 (1.06-2.63)	2.27 (1.50-3.45)	1.52 (1.03-2.25)	1.37 (0.88-2.13)	2.44 (1.61-3.69)	2.24 (1.37-3.67)	2.17 (1.31-3.59)	1.21 (0.82-1.79)
Aerobic exercise duration	0 to 100 min/wk	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	101 to 180 min/wk	0.83 (0.60-1.16)	0.78 (0.55-1.10)	0.80 (0.59-1.08)	0.74 (0.52-1.06)	0.80 (0.57-1.11)	0.95 (0.62-1.45)	0.86 (0.56-1.31)	1.12 (0.83-1.51)
	181 to 290 min/wk	0.98 (0.70-1.37)	0.92 (0.67-1.28)	0.81 (0.60-1.09)	0.93 (0.66-1.30)	0.80 (0.58-1.10)	1.08 (0.71-1.62)	1.03 (0.69-1.55)	1.35 (1.01-1.82)
	≥291 min/wk	0.83 (0.58-1.19)	0.89 (0.63-1.25)	0.87 (0.64-1.19)	0.75 (0.53-1.06)	0.72 (0.51-1.01)	1.30 (0.85-1.99)	1.02 (0.67-1.55)	1.45 (1.06-1.98)

(*continued on next page*)

Table 3. Factors associated with dietary and nutritional supplement use among Navy and Marine Corps personnel[a] *(continued)*

Variable	Strata	Dietary Supplements Taken 1 or More Times per Week: Any DS[b]	Use of ≥5 DSs	MVM[c]	Protein or AA[d]	Combination products	Herbal	≥$50 Spent on DSs per month	Any NS[e] taken 1 or more times per week
Resistance training duration	0 to 45 min/wk	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	46 to 135 min/wk	1.27 (0.94-1.74)	1.78 (1.25-2.53)	1.34 (1.00-1.79)	2.16 (1.48-3.16)	1.63 (1.16-2.29)	1.18 (0.79-1.76)	2.25 (1.42-3.56)	1.38 (1.04-1.83)
	136 to 270 min/wk	2.37 (1.65-3.40)	3.17 (2.19-4.59)	1.92 (1.40-2.65)	5.16 (3.49-7.62)	3.20 (2.23-4.59)	1.49 (0.97-2.28)	4.30 (2.68-6.91)	1.35 (0.99-1.86)
	≥271 min/wk	2.85 (1.94-4.17)	4.90 (3.35-7.17)	2.12 (1.51-2.96)	9.15 (6.10-13.73)	4.74 (3.26-6.88)	0.92 (0.57-1.48)	6.63 (4.08-10.77)	1.42 (1.02-1.98)
Service	Marine Corps	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Navy	0.78 (0.61-1.00)	0.95 (0.75-1.21)	0.97 (0.78-1.20)	0.93 (0.72-1.19)	0.85 (0.67-1.08)	0.96 (0.71-1.30)	0.85 (0.63-1.15)	0.71 (0.57-0.88)

[a]Multivariate logistic regression.
[b]DS=dietary supplement.
[c]MVM=multivitamin/multimineral.
[d]AA=amino acid.
[e]NS=nutritional supplement.
[f]HS=high school.
[g]Calculated as kg/m^2.

supplement use. Higher levels of weekly aerobic or resistance training were generally associated with increasing sport drinks and sport bars/gels consumption. A greater proportion of Special Operations personnel and Marines reported using nutritional supplements. More Special Operations personnel reported using sport bars/gels and a greater proportion of Marine Corps personnel reporting consuming sport drinks.

Table 2 also reports the total dollars spent on dietary supplements during the past 6 months, and the proportion of the population spending ≥$50 on dietary supplements each month by demographic, military, and physical activity characteristics. Those spending more dollars on dietary supplements each month included men, those of lower education level, enlisted service members (compared with officers), those with higher BMI, those performing more aerobic or resistance exercise, and Marines. These same groups had a greater proportion of individuals spending >$50/mo; Special Operations personnel were also more likely to spend >$50/mo.

Table 3 shows the results of the multivariate logistic regression examining factors associated with dietary supplement use. Factors independently associated with use of any dietary supplement, use of five or more dietary supplements, and MVMs included female sex, higher educational level, higher BMI, and longer weekly duration of resistance training. Protein/AA use was independently associated with male sex, higher educational level, BMI of 25.0 to 29.9, and longer weekly resistance training. Combination product use was independently associated with higher BMI and more weekly resistance training. Herbal supplement use was independently associated with female sex and higher BMI. Factors independently associated with spending ≥$50/mo on dietary supplements included higher BMI and more weekly resistance training. Nutritional supplement use was associated with male sex, longer weekly duration of aerobic and resistance training and Marine Corps affiliation.

Adverse Events

Table 4 shows the prevalence of AEs reported by service members. The prevalence in Table 4 is the proportion of the population consuming the listed product who reported experiencing the AE. The proportion of service members reporting one or more AEs (%±standard error) was 22.1%±1.2% for dietary supplements and 5.6%±0.8% for nutritional supplements (data not shown in Table 4). In rank order, the supplement types eliciting the most to least percentage of AEs were combination products, purported prohormones, herbals, meal-replacement drinks, and MVMs. If combination products were excluded, 13.0%±1.0% of the users of other dietary supplements reported one or more AEs. The proportion of service members reporting AEs with specific combination products was 64% (AE n=16/user n=25) for OxyElite Pro (USP Labs), 43% (AE n=6/user n=14) for Roxylean (BPI Sports), 42% (AE n=18/user n=43) for NO-Xplode (Bioengineered Supplements), 40% (AE n=22/user n=55) for Hydroxycut Hardcore (Inovate Health Science International), 40% (AE=8/user n=20) for Hydroxycut Advanced (Inovate Health Science International), 38% (AE n=3/user n=8) for D4 Thermal (Cellucor), and 35% (AE=45/user n=128) for C4 Extreme (Cellucor). There was little difference between Marine Corps and Navy personnel in the incidence of overall AEs for dietary supplements (P=0.36) or nutritional supplements (P=0.69).

Survey Responders and Nonresponders

Survey responders were older (31±8 vs 27±7 years; $P<0.01$), and more likely to be women (21% vs 17%; $P<0.01$), married (22% vs 13%; $P<0.01$), and had some college or higher education (28% vs 15%; $P<0.01$). Officers and warrant officers were more likely to complete the survey than enlisted personnel (31% vs 15%; $P<0.01$), although senior enlisted were more likely than junior enlisted to respond (20% vs 11%; $P<0.01$). Of 10 occupational groups, those more likely to respond were medical/health care (27%), support and administration (21%), electrical repair (21%), and infantry (20%). There was little difference in the proportion of responders between Navy and Marine Corps personnel (18% vs 17%; $P=0.16$).

DISCUSSION

The prevalence of dietary supplement use in Marine Corps and Navy personnel was high, with 73% using at least one dietary supplement one or more times per week and 31% using five or more dietary supplements one or more times per week. Factors independently associated with use of any dietary supplement and use of five or more dietary supplements per week included female sex, higher educational level, higher BMI, and greater weekly duration of resistance training. When individual types of supplements were examined, men were more likely than women to use protein/AAs and nutritional supplements, and women were more likely to use MVM and herbal products. MVM and protein/AA use was greater among those with higher educational level, higher BMI, and greater weekly duration of resistance training. At least one AE was reported in association with dietary supplement use in 22% of the service members, with the largest number reported by combination product users. Only 6% of nutritional supplement users reported AEs.

Prevalence and Types of Dietary Supplement Use

Dietary supplement use by the service members in this investigation demonstrated a different pattern of use compared with that of the general US population, as reported in the National Health and Nutrition Surveys (NHANES). In making comparisons, it is important to keep in mind that the NHANES sample was older and the reporting timeframe differed: the NHANES survey asked participants about any use in the last month, and the current study examined use one or more times per week in the past 6 months. In the NHANES data, overall dietary supplement use prevalences of 23%, 24%, 34%, 49%, and 48% were reported in the surveys conducted in 1987, 1992, 2000, 2003 to 2006, and 2007 to 2008, respectively.[4,24,25] For MVMs, prevalences during similar periods were 17%, 19%, 28%, 33%, and 32%, respectively.[24-26] Even the most recent NHANES prevalences were considerably lower than those found in the current study, which were 73% for any dietary supplement and 48% for MVMs. The 2003 to 2006 NHANES data also indicated that only 4% of the general population used AA supplements and 14% used herbals in the last month[25] compared with 34% and 15% of service members, respectively, who reported using them in the current study. Thus, compared with national samples, service members in the present study had a much higher use of dietary supplements, especially MVMs and proteins/AAs, but similar use of herbal substances.

The current study found similarities and differences with data collected from other military services. A systematic review and meta-analysis of dietary supplement use in the military showed that the Army personnel had the lowest overall use of dietary supplements with 55% of men and 65% of women reporting use, and other military services had higher use of about 60% for men and 73% for women.[2] Much of these data were collected more than 10 years ago. More recently, overall use rates of any dietary supplement in the Air Force[18] and Coast Guard[19] were shown to be 68% and 70%, which is slightly lower but similar to the 73% reported here. In comparing other categories of dietary supplements, the Air Force and Coast Guard data are very similar for the use prevalence of MVMs (approximately 47%), proteins/AAs (approximately 33%), and other dietary supplements (approximately 25%), but the service members in the current study used more individual vitamins/minerals (29% vs 22%), herbal substances (15% vs 8%), and purported prohormones (4% vs 1%).

The only previous study of Navy and Marine Corps personnel was conducted in 2005 as part of the Department of Defense Survey of Health Related Behaviors,[27] which, like the current study, employed a random sample of service members. Table 5 shows a comparison of this Department of Defense study[27] with that of the current investigation. Caution must be exercised in interpretation because of differences in questionnaire structures, definition of DS categories, and the fact that the Department of Defense study reported weighted prevalence rates while the current study does not involve a weighted sample. The prevalence of any dietary supplement use was ≥10% higher in the current study compared with that of Bray and colleagues,[27] and dietary supplement use was higher in all comparable categories, with the exception of joint health products. Temporal trends indicating increasing use of dietary supplements over time have been observed in civilian studies, as noted here.[3,24,25] Cassler and colleagues[28] collected data in 2011 among a convenience sample of deployed Marines and found that 72% of men (n=310) and 42% of women (n=19) reported using dietary supplements in the last 30 days.

Factors Associated with Dietary Supplement and Nutritional Supplement Use

Both civilian[3,4,9,24,25,29-31] and military[2,17-19] investigations have generally found that women and those with of higher educational levels are more likely to use dietary supplements. In our study, the sex effect was marginal in the univariate analysis, but in the multivariate analysis female sex was strongly associated with dietary supplement use, especially for MVMs and herbal supplements; educational level was associated with dietary supplement use in both univariate and multivariate analyses, especially for MVMs and vitamins/minerals. Sex differences may be associated with psychosocial factors relating to greater health awareness in women: numerous studies have shown that, compared with men, women are more active consumers of medical care[32-34] and are generally more likely to make lifestyle changes in an effort to improve their health.[35,36] However, diverging from the general trend, men in our study used proteins/AAs to a greater extent than women. This may be related to the fact that active men are more interested in the development of

Table 4. Prevalence of adverse events reported by Navy and Marine Corps personnel

	Adverse Events										
Category	Palpitations	Abdominal pain	Nausea, vomiting	Diarrhea	Muscle cramps pain or weakness	Sleep problems, insomnia	Dizzy, confused, lightheaded	Tingling, numbness	Seizure, convulsion, tremor	Other	Individuals reporting 1 or more adverse events
Dietary supplement	*%±standard error (n)*										
MVM[a] (n=808)	0.7±0.3 (6)	1.0±0.4 (8)	3.2±0.6 (26)	1.5±0.4 (12)	0.5±0.2 (4)	0.6±0.3 (5)	0.5±0.2 (4)	0.4±0.2 (3)	0.0±0.0 (0)	3.2±0.6 (26)	8.4±1.0 (68)
Individual vitamin/mineral (n=488)	0.8±0.4 (4)	0.6±0.3 (3)	1.2±0.5 (6)	0.6±0.3 (3)	0.0±0.0 (0)	0.4±0.3 (2)	0.4±0.3 (2)	0.6±0.3 (3)	0.2±0.2 (1)	2.5±0.7 (12)	5.3±1.0 (26)
Protein or amino acid (n=566)	0.7±0.4 (4)	0.9±0.4 (5)	0.9±0.4 (5)	1.8±0.6 (10)	0.2±0.2 (1)	0.5±0.3 (3)	0.2±0.2 (1)	0.2±0.2 (1)	0.2±0.2 (1)	3.2±0.7 (18)	7.4±1.1 (42)
Combination products (n=555)	15.9±1.6 (88)	3.2±0.7 (18)	2.9±0.7 (16)	4.5±0.9 (25)	2.2±0.6 (12)	5.8±1.0 (32)	4.7±0.9 (26)	9.9±1.3 (55)	0.9±0.4 (5)	5.8±1.0 (32)	28.8±1.9 (160)
Herbal (n=257)	2.3±0.9 (6)	2.3±0.6 (6)	0.8±0.4 (2)	0.4±0.3 (1)	0.8±0.4 (2)	1.2±0.5 (3)	1.2±0.5 (3)	0.8±0.4 (2)	0.4±0.3 (1)	5.1±0.9 (13)	8.9±1.9 (23)
Purported prohormone (n=64)	1.6±1.6 (1)	0.0±00 (0)	0.0±0.0 (0)	1.6±1.6 (1)	1.6±1.6 (1)	1.6±1.6 (1)	1.6±1.6 (1)	3.1±2.2 (2)	0.0±0.0 (0)	6.3±3.0 (4)	9.4±3.6 (6)
Joint health product (n=135)	0.0±0.0 (0)	1.5±1.0 (2)	0.7±0.7 (1)	0.7±0.7 (1)	0.7±0.7 (1)	0.7±0.7 (1)	0.0±0.0 (0)	0.0±0.0 (0)	0.0±0.0 (0)	2.2±1.3 (3)	5.9±2.0 (8)
Other (n=457)	0.0±0.0 (0)	0.7±0.4 (3)	0.4±0.3 (2)	0.7±0.4 (3)	0.2±0.2 (1)	0.9±0.4 (4)	0.2±0.2 (1)	0.0±0.0 (0)	0.0±0.0 (0)	1.8±0.6 (8)	4.6±1.0 (21)
Nutritional supplement											
Sport drink (n=749)	0.4±0.2 (3)	0.4±0.2 (3)	0.4±0.2 (3)	0.7±0.3 (5)	0.4±0.2 (3)	0.4±0.2 (3)	0.3±0.2 (2)	0.1±0.1 (1)	0.0±0.0 (0)	1.9±0.5 (14)	3.7±0.7 (28)
Sport bar/gel (n=383)	0.0±0.0 (0)	0.8±0.5 (3)	0.3±0.3 (1)	1.0±0.5 (4)	0.3±0.3 (1)	0.0±0.0 (0)	0.3±0.3 (1)	0.0±0.0 (0)	0.0±0.0 (0)	1.6±0.6 (6)	3.1±0.9 (12)
Meal-replacement drinks (n=115)	0.0±0.0 (0)	0.9±0.9 (1)	2.6±1.5 (3)	1.7±1.2 (2)	1.7±1.2 (2)	0.9±0.9 (1)	0.0±0.0 (0)	0.0±0.0 (0)	0.0±0.0 (0)	4.3±1.9 (5)	8.7±2.6 (10)

[a]MVM=multivitamin/multimineral.

Table 5. Comparison of dietary supplement prevalence in Navy and Marine Corps personnel in current study with that of Department of Defense study of health-related behaviors[a]

Military service	Any DS[b]		MVM[c]		Any Individual Vitamin/Mineral		Herbals		Joint Health Products	
	Bray, 2006[27]	Current study	Bray, 2006[27]	Current study	Bray, 2006[27]	Current study	Bray, 2006[27]	Current study	Bray, 2006[27]	Current study
	←————				*%±standard error*					————→
Marines	61±1.2	74±1.4	42±1.2	48±1.6	25±1.2	29±1.4	12±0.7	15±1.1	8±0.6	8±0.9
Navy	61±1.1	71±1.7	48±1.1	49±1.9	28±1.7	30±1.7	13±0.9	15±1.4	10±0.5	8±1.0

[a]The Bray[27] study differed from the current study in questionnaire structure and reported weighted prevalence rates.
[b]DS=dietary supplement.
[c]MVM=multivitamin/multimineral.

strength and muscle mass[37-39] and studies have shown that appropriate physical training in conjunction with judicious protein/AA supplementation will result in improved muscle mass and strength.[40] With regard to the association between dietary supplements and education, individuals who have achieved higher educational levels are generally more health conscious, more prone to engage in health-promoting behaviors, and more likely to explore multiple channels of information related to their health[41-44] that can lead to higher use of supplements.

In contrast to sex and education level, studies on BMI and dietary supplement use have been conflicting.[3,17,18,31] In general agreement with Army data,[17] the multivariate analysis in the present investigation found a linear response effect, such that the higher the BMI, the greater the overall use of dietary supplements, and especially for MVMs, combination products, and herbal substances. Service members with high BMI were also more likely to use five or more dietary supplements and spend >\$50/mo. There are strict weight-for-height and body fat requirements for continued service in the Army, Marine Corps, and Navy that are described in service regulations.[45-47] Individuals who do not meet these standards receive adverse performance reports and can be discharged from service for repeated failures to achieve the standard. This might prompt some individuals who are marginal with regard to meeting these height/weight and body fat standards to use dietary supplements promoted to assist with weight or body fat control.

In many prior investigations, those who were more physically active were more likely to use dietary supplements.[3,17-19,30,48] The current study found a strong relationship between dietary supplement use and resistance training but few relationships with aerobic training. The discrepancies in the literature can possibly be explained by different definitions of physical activity and the fact that some past studies[3,30,48] did not adequately distinguish between different modes of physical training (eg, aerobic vs resistance) that might influence which types of dietary supplements are used. In the present study, service members were specifically asked to report separately on their aerobic and strength/resistance training frequency and duration and the weekly training duration of both exercise modes were calculated. Previous studies in the Army, Air Force, and Coast Guard personnel have shown that, when considered on a dichotomous basis, those performing resistance training were more likely to use dietary supplements than those not performing this type of training.[17-19] In the present study, four levels of resistance training duration were examined and a very strong dose−response relationship was found between resistance training duration and use of any dietary supplement/nutritional supplement, protein/AAs, combination products, purported prohormones, sport drinks, sport bars/gels, and money spent on dietary supplements. These relationships were present even after controlling for a number of other factors in a multivariate analysis (multivariate data for some categories are not shown).

Nutritional supplements were used to a larger extent by those performing more aerobic and resistance training. This was because there was greater use of sport drinks and sport bars/gels in the more active service members, in consonance with data reported in other military services.[17-19] Sport

drinks containing up to about 8% carbohydrate and consumed at a rate of about 1 L/h have been shown to maintain blood glucose levels (a major factor in long-term fatigue) and delay fatigue when exercise is performed for >1 hour.[49] Sport drink consumption during shorter-term exercise is probably not necessary, but can benefit hydration, albeit in a manner similar to water.[50,51] Consumption in the post-exercise period is advantageous for both rehydration and optimal repletion of muscle and liver glucose.[52-54] Carbohydrate gels consumed before or during physical activity have been shown to improve some aspects of performance.[55,56] Like sport drinks, post-exercise consumption (within about 1 hour) of bars or gels will lead to greater repletion of muscle glycogen because post-exercise glucose transport and the activity of glycogen synthase (the rate-limiting enzyme for glycogen resynthesis) are considerably augmented.[57,58]

Adverse Events

Timbo and colleagues[9] examined AEs reported in the 2002 Health and Diet Survey, a telephone interview of a nationally representative sample. They asked about vitamins, minerals, proteins, and herbal substances in the last 12 months and only 4% of the sample reported AEs. In the present study, if only MVMs, single vitamins/minerals, proteins/AAs, and herbals were included, 9% of service members reported AEs. Previous studies of military personnel found AE prevalences ranging from 8% in Air Force personnel to 20% in deployed British service members.[7-9,28,59-61] Both Brasfield[7] and Corum[8] found that 18% reported AEs in separate broad surveys of Army personnel. The 22% of service members reporting AEs is higher than previous studies. This might be because of questionnaire design and the broader range of dietary supplements addressed in the present study. Our questionnaire listed very specific dietary supplements and then service members were asked to recall whether they had an AE to that particular dietary supplement. Many questionnaires appear to ask for AEs without linking them to specific dietary supplements,[7,28,60,61] although the questionnaire design was not clear in some investigations.[8,59]

The dietary supplement category with the largest proportion of AEs was combination products, and the high AE prevalence for this category was also reported in a previous study of service members.[61] Combination products were those that included a number of different substances that were generally (but not exclusively) purported to assist in weight loss and/or muscle building. Combination products typically have a number of constituents that may potentiate physiological effects (eg, caffeine and guaraná) or may interact with other medications service members are ingesting. It is difficult to assume direct causality of AEs to supplements in the current study because the AEs were self-reported and can have alternative explanations.[62] Nonetheless, the proportion of service members reporting AEs was high and of concern.

The presumed weight-loss and muscle-building combination product OxyElite Pro had the highest proportion of users reporting AEs, although the number of users was relatively small (n=25). OxyElite Pro was recalled by the FDA in 2013 after reports of 29 cases of acute hepatitis and liver failure associated with this supplement in Hawaii.[63,64] OxyElite Pro contained 1,3 dimethylamylamine, which was also associated with cardiovascular events, including deaths.[65-67] One concern with FDA recalls is that they target specific dietary supplements and manufacturers can reformulate compounds, rename the new reformulation, and sell these reformulated supplements, despite the fact that they may contain substances similar to the banned dietary supplement. After OxyElite Pro was reformulated as "Super Thermogenic," case series involving liver damage from the use of this dietary supplement emerged.[68,69] In 2015, the FDA advised consumers not to use this reformulated dietary supplement because it contained a nondisclosed drug, the selective serotonin reuptake inhibitor fluoxetine.[70]

Other dietary supplements for which a number of AEs were reported included Roxylean, NO- Xplode, Hydroxycut Hardcore, and Hydroxycut Advanced, although the number of users for most of these dietary supplements was relatively small. No case reports of specific AEs in association with the use of Roxylean were found. The original formula of this dietary supplement (Roxylean ECA) contained 1,3 dimethylamylamine,[71] but the manufacturer was not contacted by the FDA in its ban of 1,3 dimethylamylamine.[14] Examination of the nutrition supplement labels of the currently available product showed that it contained no 1,3 dimethylamylamine.[72] Case reports of hepatotoxicity, ischemic colitis, and renal failure have been reported in association with the use of NO-Xplode.[73-75]

Hydroxycut products have a long history of associations with AEs. Early formulations of Hydroxycut contained ephedra.[76] Ephedra alkaloids were banned by the FDA in 2004[12] after many AEs were reported and a comprehensive literature review suggested significant "risk of psychiatric, autonomic, or gastrointestinal symptoms, and heart palpitations."[77] Despite court challenges, the ban was upheld in 2006.[78] Seizure activity and severe hepatotoxicity were reported in association with the Hydroxycut ephedra formulation.[79,80] Hydroxycut was reformulated without ephedra, but cases of hepatotoxicity[81-84] and rhabdomyolysis[85,86] were associated with this new formulation. In 2009, the FDA warned consumers to stop using specific Hydroxycut products[13] and the manufacturer voluntarily recalled some Hydroxycut-labeled products.[87] Possible hepatotoxic substances in the pre-2009 Hydroxycut formulation included *Garcinia Cambogia*, chromium, and *Camellia Senensis*.[83] Hydroxycut was again reformulated without these substances, but the older formulations still appear to be available.[88,89] Some cases of AEs continue to appear even with the newer formulation.[90,91]

Limitations

This study has limitations. All data were self-reported and suffer from the usual limitations associated with this method, including recall bias, social desirability, errors in self-observation, and inadequate recall.[92,93] Our analysis of responders and nonresponders indicated that there was some response bias. It was somewhat more likely to obtain data from women, older service members, married personnel, those of higher educational level, officers and senior enlisted personnel, and certain occupational groups. Nonetheless, individuals from all these demographic groups were well represented in the analyses.

CONCLUSIONS

Among Navy and Marine Corps personnel, 73% reported the use of dietary supplements one or more times per week. The most commonly used dietary supplements and nutritional supplements (one or more times per week) were multivitamins/multiminerals (48%), sport drinks (45%), protein/AAs (34%), combination products (33%), individual vitamins and minerals (29%), and sport bars/gels (23%). Multivariate logistic regression modeling indicated that female sex, higher educational level, higher BMI, and a greater amount of resistance training were associated with dietary supplement use. Twenty-two percent of dietary supplement users and 6% of nutritional supplement users reported one or more AEs. For combination products alone, 29% of users reported one or more AEs. The prevalence of dietary supplement use in Navy and Marine Corps personnel was considerably higher than reported in civilian investigations for almost all types of dietary supplements, although similar to most other military services. Future studies should be designed to identify dietary supplements associated with AEs documented in medical records.

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14. ABSTRACT

Background: About 50% of Americans and 60% to 70% of US military personnel use dietary supplements, some of which have been associated with adverse events (AEs). Nutritional supplements like sport drinks and sport bars/gels are also commonly used by athletes and service members. Previous dietary supplement and nutritional supplement surveys were conducted on Army, Air Force, and Coast Guard personnel.
Objective: The aim of this cross-sectional study was to investigate dietary and nutritional supplement use in Navy and Marine Corps personnel, including the prevalence, types, factors associated with use, and AEs.
Design: A random sample of 10,000 Navy and Marine Corps personnel were contacted. Service members were asked to complete a detailed questionnaire describing their personal characteristics, supplement use, and AEs experienced.
Results: In total, 1,708 service members completed the questionnaire during August through December 2014, with 1,683 used for analysis. Overall, 73% reported using dietary supplements one or more times per week. The most commonly used dietary supplements (used one or more times per week) were multivitamins/multiminerals (48%), protein/amino acids (34%), combination products (33%), and individual vitamins and minerals (29%). About 31% of service members reported using five or more dietary supplements. Sport drinks and sport bars/gels were used by 45% and 23% of service members, respectively. Monthly expenditures on dietary supplements averaged $39; 31% of service members spent ≥$50/mo. Multivariate logistic regression modeling indicated that female sex (women/men; odds ratio [OR]=1.76, 95% CI 1.32 to 2.36), higher educational level (college degree/no college degree; OR=2.23, 95% CI 1.62 to 3.30), higher body mass index (calculated as kg/m2) (≥30/<25; OR=1.67, 95% CI 1.06 to 2.63), and a greater amount of resistance training (≥271/0 to 45 min/week; OR=2.85, 95% CI 1.94 to 4.17) were associated with dietary supplement use. Twenty-two percent of dietary supplement users and 6% of nutritional supplement users reported one or more AEs. For combination products alone, 29% of users reported one or more AEs.
Conclusions: The prevalence of dietary supplement use in Navy and Marine Corps personnel was considerably higher than reported in civilian investigations for almost all types of dietary supplements, although similar to most other military services. Factors associated with dietary supplement use were similar to those reported in previous military and civilian investigations. Prevalence of self-reported AEs was very high, especially for combination products.

15. SUBJECT TERMS

multivitamin/multimineral, vitamin, mineral, prohormone, sports drinks, sports bars/gels

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